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PV LED ENGINE CHARACTERIZATION LAB FOR STANDALONE LIGHT TO LIGHT SYSTEMS

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ABSTRACT: PV-powered lighting systems, light-to-light systems (L2L), offer outdoor lighting where it is elsewhere cumbersome to enable lighting. Application of these systems at high latitudes, where the difference in day length between summer and winter is large and the solar energy is low requires smart dimming functions for reliable lighting. In this work we have built a laboratory to characterize these systems up to 200 Wp from “nose to tail” in great details to support improvement of the systems and to make accurate field performance predictions.

Keywords: Solar cells, PV applications, Characterization, Energy Systems

1 INTRODUCTION

Light-to-light systems are typically solar powered stand-alone lamps using LEDs as light source. Park lights and bollards are examples of L2L systems and these systems offers lighting solutions, for places where lighting is not feasible due to very high cabling costs of e.g. 700 €/m in Copenhagen. At low latitudes dimensioning of such products is relatively easy, since there is plenty of sun and the difference between day length between summer and winter is small. However in locations further away from equator, the difference in day length between summer and winter increases, and the solar potential is less. Therefore construction of reliable lighting with feasible dimensions requires intelligent harvesting and efficient usage of energy becomes crucial [1]. Since high power MPPT-charge regulators are not subjected to any standards e.g. [2] not all charge regulators comply with the manufactures specification [3], and within this work low maximum power point tracking (MPPT)-efficiencies of commercially available regulators are measured, and therefore this work emphasize the importance of full system testing.

In this work we have build a laboratory where we can measure all the parts of such light-to-light systems, and use the data for optimization of products and accurate prediction of field performance.

2 THE LAB

2.1 IV Characterization

A Newport class AAA solar simulator is used for illumination of the panels, and IV-curves from 50 W/m² to 1000 W/m² are recorded, using a Keithley 2401 SourceMeter for small panels. An example of such series of measurement is shown in Figure 1.

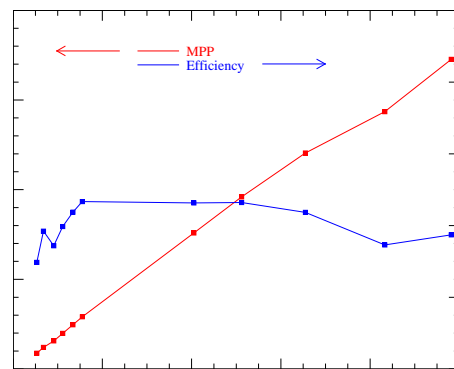


Figure 1: Measurement of the Solar panel at different illumination levels. An IV-curve is recorded for each measurement point.

2.2 Electronic characterization

We characterize 4 electronics features on the electronic controller board:

- The MPP-tracking efficiency.
- The Charge conversion efficiency.
- The efficiency of the LED supply.
- The standby consumption.

The electronic characterization lab consists of 3 different emulators and a 3 channel power analyzer to measure the power flow. The equipment is as follows:

- Two Agilent B2962 - 2 Channel programmable source measure unit, 30 W pr. channel. The channels are floating enabling serial and parallel connection of the channels.
- One Agilent Solar Array Simulator E4360A mainframe with a E4361A DC module (0-65 V and 0.8.5 A).
- One Keithley 2651A High Power SourceMeter (200 W 2000 W pulsed).
- One Tektronix Power Analyzer PA4000 3CH.

The charge part of the characterization is done using either an Agilent E4361A Solar Array Simulator for larger PV modules and for smaller PV modules an Agilent B2962 Source Measure Unit (SMU) as an emulator. The SAS is not very accurate for power levels

under 5 - 10 watts. As battery the Keithley 2651A Source meter is used in constant voltage mode and since charge currents is typically below 0.2 C the constant voltage emulates the battery fairly well. The devices supports though more advanced battery emulation.

All voltages and currents are measured using the power analyzer.

As input to the solar emulators the measured sets of V_{OC} , I_{SC} , V_{MP} and I_{MP} , recorded at different light intensities are used. The set of IV-curve parameters is measured for different relevant battery voltages, and thereby a full mapping of the working ranges is obtained for a specific system. The measurement and data acquisition is automated in LabVIEW.

Based on these measurements the tracking efficiency and the conversion efficiency are obtained and examples are shown in figures 2 and 3.

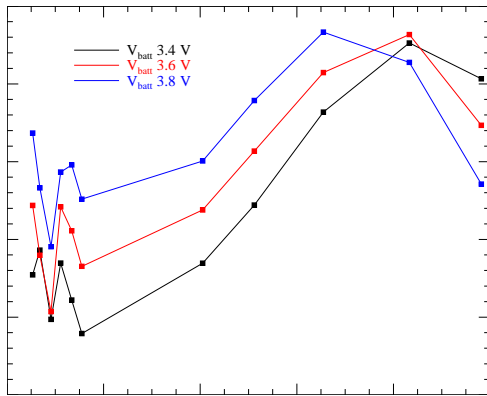


Figure 2: The powerpoint tracking efficiency as a function of irradiation. The efficiencies above 100 %, is explained by the accuracy of the emulator, in this case the Agilent E436x SAS system.

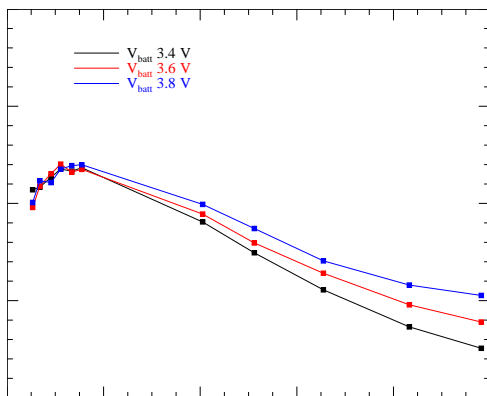


Figure 3: The conversion efficiency of the charger. This charger seems to be optimized for low power.

The LED driver is also tested by letting the Keithley 2651A emulate a battery in constant voltage mode, vary the battery voltage and using the real LED as sink. The system tested here is simple without a clock and therefore it turns the LED on once the PV Energy is decreased to zero. Therefore, for this system, a LED output can be

stimulated with a constant battery voltage and a solar input for a short while e.g. a minute. The LED output is stimulated after the solar input is turned on. However some controllers are time based why it is sometimes hard to stimulate a LED output for the controller.

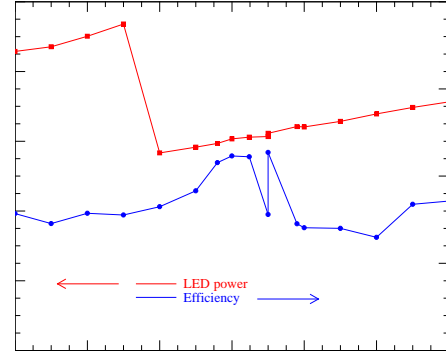


Figure 4: The LED driver efficiency and Power. The sudden decrease in power level at 3.5 volts has no explanation, but is a reproducible system behaviour.

The Power analyzer has a special standby mode, where it measures the standby power by integrating the power over a period set by the user with a very high sampling rate and then output the average power. With a similar approach as for the LED driver, the standby power consumption can be measured when the LED is disconnected. The measurement in figure 3 also includes the standby power in the efficiency calculation and therefore this measurement provides sufficient information for a field performance prediction. However, the standby power consumption measurement is a powerful tool to differentiate the converter loss and standby power consumption enabling a more targeted product improvement.

2.3 Battery characterization

Charge and discharge curves are recorded using an ELV ALC 8500 Expert battery tester. This device can charge and discharge the battery at a specified rate, and record the data, and an example of such measurement is showed in figure 5.

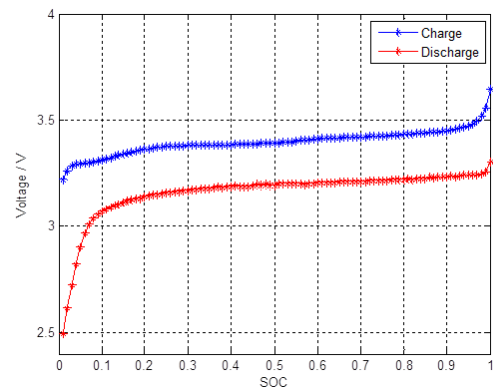


Figure 5: Charge and discharge curve of a NiMH battery.

2.4 Luminaire testing

The LED is characterized at DOLL quality lab [4], where both a goniophotometer (Techno Team, Rigo 801), and an integrating sphere (Instrument Systems, ISP 1000 and ISP 2000), which are both equipped with a spectrometer (Instrument Systems, CAS 140, 380-1040 nm) and a high quality luxmeter (PRC Krochman, $f_1' < 1.2$).

The integrating sphere measures the total luminous flux, and the goniophotometer measures the light distribution from a luminaire.

Figure 6 shows an example of a measurement in the integrating sphere, where the luminous flux is measured as a function of voltage and current.

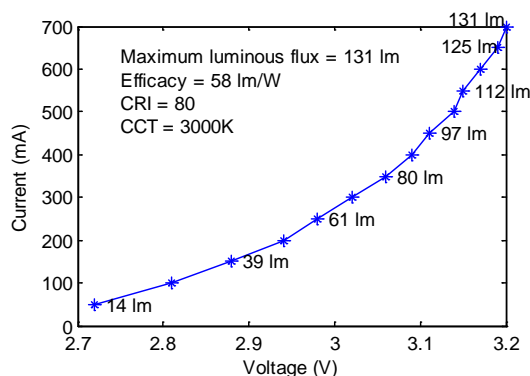


Figure 6: Characterization of an LED

3 MEASUREMENTS

A measurement on a commercial high end PV powered LED lighting bollard system was done, and the results can be found in figures 1-6. The average conversion efficiency is 78% and the tracking efficiency is 93.5 % giving the controller a total charging efficiency of 72 %. The average battery efficiency is 94 % and the average LED driver efficiency is 77% i.e. approximately only 53% of the incoming electric power is available for the LED.

4 CONCLUSION

These preliminary measurements provide a deep insight in the losses and the behavior of these smaller light-to-light systems. Further the preliminary measurements indicate that the electronic controller in the L2L systems has the highest potential for improvement.

Future work includes, implementing the shown laboratory measurement in the PV LED engine software [5], and use these data for accurate field prediction.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

[1] Edoardo Cavallaro et. A;, Dimming Based

Energy Management of PV-Fed LED Lighting System, presented at PCIM Europe 2012.

[2] EN 50530: Overall efficiency of grid connected photovoltaic inverters.

[3] Michael Müller et. Al; Performance of MPPT Charge.

[4] Danish Outdoor Lighting Lab; www.lightinglab.dk/UK/

[5] Poulsen et. Al; Simulation tool for designing off-grid PV applications for the urban environment, presented at the 28. EUPVSEC 2013, Paris